L-3/T-2/ME **Date : 07/08/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2014-2015

Sub : **IPE 331** (Production Processes)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Briefly describe the properties that determine the quality of a sand mold for sand casting. What is the difference between a pattern and a core in sand molding? **(12)**

   (b) With the help of suitable diagrams, describe the following: **(24)**

   (i) Centrifugal casting

   (ii) Gating system

   (iii) Gravity die casting

   (c) Name various defects in castings with suitable diagrams. Why is it important to remove dross or slag during the pouring of molten metal into the mold? Explain briefly. **($10\frac{2}{3}$)**

2. (a) Show by simple diagram, the shear angle associated with machining ductile metal. How is the value of that shear angle affected by tool rake angle and chip thickness in a given machining condition? **(12)**

   (b) Prove that the maximum main cutting force (P_z) in an orthogonal cutting is $2\tau_s S_0 t\cot\beta$ if $2\beta + \eta - \gamma = \pi/2$. **(12)**

   (c) A mild steel rod of 150 mm diameter is turned on a lathe at a speed of 340 rpm, feed of 0.24 mm/rev and 2.5 mm depth of cut by a tool having tool rake angle 20° and principal cutting edge angle 60°. It is found by the dynamometer that the main cutting force = 800 N and feed force = 400 N. The value of chip reduction coefficient is 3.5. Calculate the coefficient of friction, shear plane angle, chip velocity and dynamic yield shear strength. **(12)**

   (d) What conditions of machining and cutting tool indicate that a cutting tool has failed? Explain briefly. What properties should a cutting tool material essentially posses and why? **($10\frac{2}{3}$)**

3. (a) Sketch the various weld joints and welds used in making a joint. Describe the shielded metal arc welding process. **(12)**

Contd P/2

IPE 331 (ME)

Contd... Q. No. 3

(b) With the help of suitable diagrams, describe the following: **(24)**

(i) Submersed arc welding

(ii) Resistance seam welding

(iii) Resistance projection welding

(c) Describe the features of a weld nugget. Explain the similarities and differences between electron beam and laser beam welding. Given typical application for each. **(10⅔)**

4. (a) Explain why a casting may have a slightly different shape than the pattern used to make the mold. Explain the difference in the importance of drafts in green sand casting versus die mold casting. **(12)**

(b) What are the standard angles of cutting tool? Explain them with suitable diagram. Why do the chip and tool-tip become very hot during machining metal? **(12)**

(c) State the purpose of determining the magnitude and other characteristics of the cutting forces that develop during various kinds of machining work. Why can blind risers be smaller than open risers? **(12)**

(d) Distortion is a serious problem in fusion welding, particularly arc welding. What measures can be taken to reduce the incidence and extent of distortion? Explain briefly. **(10⅔)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What are the different operations that can be performed on a lathe? Explain any five in detail. **(12)**

(b) With the help of neat sketch, describe the method of taper turning by offsetting the tailstock in a lathe machine. **(10)**

(c) Briefly describe the parameters, which influence the performance of a grinding wheel. **(18)**

(d) Write short note on spade drill and gun drill. **(6⅔)**

6. (a) Discuss the gear cutting process in milling machine. Also discuss the necessity of change gear box in gear cutting. **(16⅔)**

(b) With neat sketches, show the constructional features of a twist drill and label the important features. **(13)**

Contd P/3

Contd... Q. No. 6

(c) Describe the quick return motion mechanism of hydraulic shaper with necessary sketches. **(10)**

(d) Differentiate between up-milling and down-milling. **(7)**

7. (a) Discuss commonly observed forging defects. **(12⅔)**

(b) Explain thread rolling process and ring rolling process with suitable diagram. **(12)**

(c) How roll force can be reduced in flat rolling? What measures can be taken to avoid the bending of rolls in flat rolling? **(12)**

(d) Describe steel ball production process with neat sketches. **(10)**

8. (a) Derive the expression for optimum cutting speed to minimize unit production cost in turning operation. **(12⅔)**

(b) Discuss the relative advantages and disadvantages of direct extrusion and indirect extrusion process with necessary sketches. **(10)**

(c) With the help of suitable diagrams, discuss different sheet metal bending operations. **(12)**

(d) How will you manufacture an aluminum beverage can using metal forming processes? Explain each process with neat sketches. **(12)**

L-3/T-2/MME **Date : 17/07/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2014-2015

Sub : **MME 345** (Foundry Engineering)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer **Q. No. 1** and any **TWO** from the rest.

Question #1 is Compulsory.

1. A foundry received an initial order of 10,000 pieces of castings made of A356 aluminium alloy of dimensions shown in Fig. 1 with a possibility of repeat order.

   (a) It was decided to use greensand moulding system and, for that, to produce a master pattern made of aluminium from which steel working patterns were to be cast and machined. Using necessary allowances, determine the dimensions of the master pattern and its core prints. **(10+10=20)**

   (b) Using modulus method, design a suitable feeding system for the casting. Indicate clearly the type of placement of feeder in the gating system. **(15+5=20)**

   (c) Design a suitable gating system for the casting using a naturally pressurized gating system with a gating ratio of 1.0: 1.2: 1.4. Assume reasonable values for missing data. Indicate all basis and assumptions you used during the design. **(15+5=20)**

2. (a) List the resistances to heat flow from the interior of the casting during solidification. Analyse the suitability of using chill and fin to enhance the transfer of heat from the liquid metal. **(3+15=18)**

   (b) Using neat sketches discuss how columnar, equiaxed and other grain structures are developed during cooling of a pure metal ingot. **(10)**

   (c) Why do you prefer fine-grained equiaxed structure in castings and ingots? How an ingot structure consists entirely of fine-grained equiaxed crystals can be developed. **(2+10=12)**

3. (a) Explain the concept of undercooling. Deduce expressions indicating the relations between undercooling and critical radius and critical Gibbs free energy change during formation of a spherical nucleus inside a liquid metal. **(5+15=20)**

   (b) Explain the term fluidity of liquid metal in casting. Examine how mode of solidification and solidification time control fluidity of liquid metal. **(5+15=20)**

4. (a) Classify casting alloys based on their solidification behaviour. Which one of them requires feeding most? What happens to a poorly fed casting? **(3+2+15=20)**

   (b) What are gating systems? Analyse the functions of a good gating system. **(2+10=12)**

   (c) Explain how surface tension of liquid metal controls filling of thin-sectioned mould. **(8)**

Contd P/2

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Discuss the casting rules that are followed to obtain good quality castings. **(15)**

(b) Compare sand casting, investment casting and permanent mould casting processes. **(15)**

(c) Different organic and inorganic materials are added to impart certain properties of green sand mould. Write the name of the materials to be added in the green sand to obtain the following properties: **(12)**

(i) increased collapsibility, (ii) reduced expansion problems, (iii) increased dry strength, (iv) increased hot strength (v) improved surface finish.

(d) What factors affect the graphitization process in cast iron besides chemical composition? **(4⅔)**

6. (a) Classify the cast irons and terms of microstructure and chemical composition (C and Si%) **(15)**

(b) What is inoculation? How are inoculants added in gray iron to modify the structure and properties? **(10)**

(c) Mention the factors that control the graphite shape in nodular cast iron. **(6⅔)**

(d) Write down the chemical reactions occur in a cupola furnace. What are effects of temperature on the change of chemical composition of cast iron during melting? **(15)**

7. (a) Write down the green sand control properties with their resulting problems if they are not properly maintained. **(15)**

(b) What type of die casting method you will choose for low melting point metal casting? Briefly explain the process sequence of the method. **(10)**

(c) List the steps of precision casting method. **(6)**

(d) Discuss the melting and moulding practices of aluminium alloys. **(15⅔)**

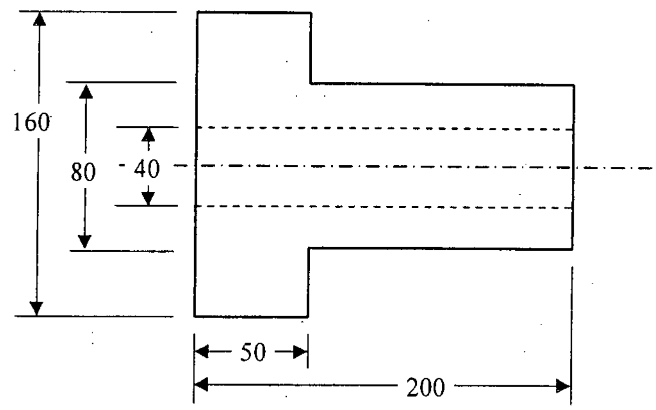
8. (a) Explain how surface films incorporate into the bulk liquid. **(20)**

(b) What is the effect of casting defects on yield strength? **(6⅔)**

(c) List the defects in casting that are produced due to the absorption of gas. Discuss the preventive measures of the defects due to absorption of gas. **(12)**

(d) Explain the design concepts that are applied to obtain sound casting. **(8)**

Fig. 1 and other Data for Q. #1



(All dimensions are in mm)

Material composition:	A356 (Al-7Si-0.3Mg)
Density:	2.70 g/cc
Moulding system:	Greensand
Pouring temperature:	700 °C
Critical gate velocity:	0.25 m/s
Solidification shrinkage:	7.0 vol. %
Coeff. of discharge:	0.80

DATA SHEET FOR PATTERN AND CORE PRINT DESIGN

Density data: Steel = 7.8, Aluminium = 2.7, Core sand = 1.6 g/cm^3

Compressive strength of core sand = 2.0 kg/cm^2; Factor of safety = 5

Data for contraction allowances:

Contraction rule	*Materials used and place of use*
+8/1000	Cast iron in general, part of thin cast iron
+9/1000	Cast iron products of high shrinkage, part of thin cast steel
+10/1000	Same as above, and aluminium
+12/1000	Aluminium alloys, bronze, cast steel (thickness 5-7 mm)
+14/1000	High tension brass, cast steel
+16/1000	Cast steel (thickness over 10 mm in general)
+20/1000	Large cast steel
+25/1000	Large cast iron

Data for general machining allowances:

Type of metal and alloys	*Machining allowance (mm)*
Cast irons	
(i) Large size castings (>1000 mm)	10.0
(ii) Medium size castings (<150 mm)	3.0
Cast steels	
(i) Large size castings (>1000 mm)	12.0
(ii) Medium size castings (<150 mm)	4.3
Non-ferrous materials	
(i) Large size castings (>1000 mm)	5.0
(ii) Medium size castings (<150 mm)	1.5

Data for approximate taper allowances:

Height of pattern mm	*Shell Moulding*	*Sand moulding*		
		Metal	*Wood*	
		Machine drawn	*Manual drawn*	*Machine drawn*
Up to 20	0° 45'	1° 30'	3°	3°
20 to 50	0° 30'	1°	1° 30'	1° 30'
:	:	:	:	:
100 to 200	0° 20'	0° 30'	0° 45'	0° 45'

L-3/T-2/ME **Date : 17/07/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2014-2015

Sub : **IPE 381** (Measurement and Quality Control)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Why is the trace obtained of the surface profile by any stylus probe instrument distorted? **(5)**

   (b) For the *constant chord* method, show that $W = \frac{\pi M}{2} cos^2 \psi$. All symbols have their usual meaning. **(10)**

   (c) Calculate the chordal addendum and chordal thickness of a gear having base circle diameter to pitch circle diameter ratio of 0.906, base pitch of 15.71 mm and a blank diameter of 143.50 mm. **(10)**

   (d) How can you turn a transparent glass into a smoked glass? Write down the functions of the following components found in a *Tomlinson* surface meter: **(10)**

   (i) Coil spring and leaf spring (ii) Cross roller (iii) Fixed rollers

2. (a) Discuss the tradeoff between Type I and Type II errors. **(5)**

   (b) Write down the axioms of probability. Explain the theorem of total probability. **(6+9=15)**

   (c) *King's Landing*, the royal capital of *Westeros*, is expected to go through an economic recession. All the gold mines it owns are currently empty. Money for *King's Landing* is supplied from two sources during an economic recession period. The sources are the *Iron Bank of Braavos* (Source *A*) and the House *Tyrell of Highgarden* (Source *B*). Data reveals that during the recessioni period, the probability that the supply from Source *A* will be below normal is 0.30; the corresponding probability for Source *B* is 0.15. However, if Source *A* is below normal, the probability that Source *B* will also be below normal during the same recession period is increased to 0.30.

   The probability of money shortage in *King's Landing* will obviously depend on the supplies from the two sources. In particular, if only Source *A* is below normal supply, the probability of money shortage is 0.20, whereas if only Source *B* is below normal the corresponding probability of shortage is 0.25. Obviously, if none of the sources are below normal, there would be no chance of shortage, whereas if both sources are below normal during the recession period, the probability of money shortage in the capital would be 0.80.

   What is the probability of money shortage in *King's Landing* during the expected recession period? **(15)**

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3. (a) If a random variable is uniformly distributed on the interval [A, B], show that its mean, $\mu = \frac{A+B}{2}$ and variance, $\sigma^2 = \frac{(B-A)^2}{12}$. **(10)**

(b) Consider a cantilever beam of span L m with a uniform load of W kg/m. The maximum shear force (S) and the maximum bending moment (M) at the fixed end are WL and $\frac{WL^2}{2}$, respectively. Consider L to be a constant and W to be a random variable with a mean of μ_W and a standard deviation of σ_W. **(10)**

(i) Calculate Cov(S, M).

(ii) Show that the correlation coefficient $\rho_{S,M} = 1$.

(iii) Using the results obtained in parts (i) and (ii), are S and M perfectly correlated?

(c) The PDF of the annual snowfall, R, of *Winterfell* is shown in Figure 3(c). **(5+2+8=15)**

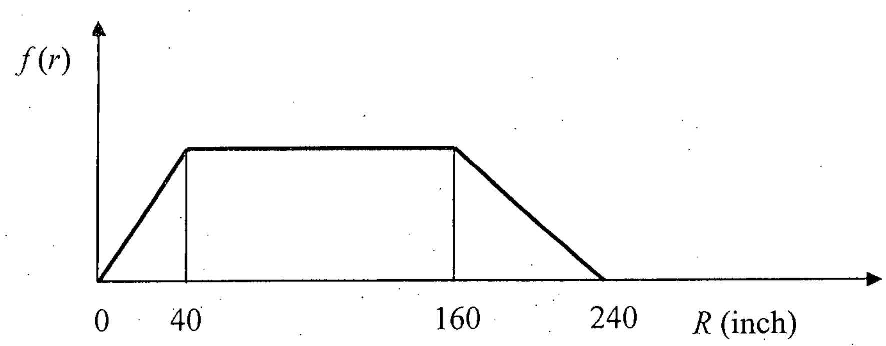

Figure 3(c)

(i) Define the PDF of R properly.

(ii) What is the mode?

(iii) Find the coefficient of variation of R.

4. (a) List the properties of a binomial process. **(5)**

(b) "Temperature in *Kelvin* scale is a ratio level variable and temperature in *Fahrenheit* scale is an interval level variable" – explain. **(5)**

(c) If $f(y|x)$ does not depend on x, then prove that $f(y|x) = h(y)$ and $f(x,y) = g(x)\ h(y)$ where the symbols have their usual meaning. **(10)**

(d) The marks obtained in IPE 381 by the students of ME batch 2012 are of interest. Ten scripts are randomly selected and tested, and the following results are obtained: (15)

Marks (out of 210)	
188	138
124	163
164	159
106	134
165	179

Contd P/3

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Contd ... Q. No. 4(d)

(i) We would like to demonstrate that the mean marks obtained exceed 160. Set up appropriate hyprotheses for investigating this claim.

(ii) Test these hypotheses using a level of significance of 0.01. What are your conclusions?

(iii) Construct a 99 percent confidence interval on the mean marks.

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Discuss how to measure the effective diameter of a screw thread using three wire method using necessary illustrations. Also derive the equations for effective dia for Whitworth thread and Metric thread in this method. **(20)**

(b) Shafts of 80 ± 0.5 mm diameter are to be checked by the help of a Go and a Not-Go snap gauge. Design the gauges, sketch it and show its Go size and a Not-Go size dimensions. Assume normal wear allowance and gauge maker's tolerance. **(15)**

6. (a) Discuss the variations in control chart. **(5)**

(b) Discuss ultrasonic inspection technique with necessary figures. **(10)**

(c) A company and its customer agreed to follow a double sampling plan. For a lot of size 2000, the first sample size has to be 30 and the second sample size has to be 60. The acceptable number of defects for the first sample is 3 and for the second sample is 5. If the fraction nonconforming is 0.02, then calculate the total probability of acceptance for that lot. **(20)**

7. (a) Discuss different aspects of quality that customers may value. **(20)**

(b) Following data shows the actual demand of a certain product for 7 consecutive months. **(10)**

Month	1	2	3	4	5	6	7
Demand	76	80	83	90	95	86	98

Mind the forecasted demand for month 8 and month 9 using linear regression technique.

(c) Discuss the differences between precision and accuracy. **(5)**

8. (a) What are the types of uncertainty? Explain with examples. **(5)**

(b) Unoccupied seats on flights cause airlines to lose revenue. A large airline wanted to estimate its average number of unoccupied seats per flight. Based on a random sample of flights, the 95% confidence interval for mean number of unoccupied seats per flight was

Contd P/4

IPE 381

Contd … Q. No. 8(b)

given as: (7.5, 9.5). Answer the following questions. Do not perform any calculation for parts (ii) to (v). **(10)**

(i) What was the mean number of unoccupied seats per flight for the sample of flights?

(ii) Based on the 95% confidence interval, what would be the decision for testing $H_0 : \mu = 7$ versus $H_1 : \mu \neq 7$ at the 5% significance level?

(iii) What would be the decision for testing $H_0 : \mu = 7$ verses $H_1 : \mu \neq 7$ at the 10% significance level?

(iv) Based on the 95% confidence interval, what would be the decision for testing $H_0 : \mu = 9$ verses $H_1 : \mu \neq 9$ at the 5% significance level?

(v) What would be the decision for testing $H_0 : \mu = 9$ verses $H_1 : \mu \neq 9$ at the 1% significance level?

(c) The northbound bus traffic (going to *Dhaka North City Corporation* from *Dhaka South City Corporation*) at *New-market* bus station between 7 and 8 a.m. on a typical workday is studied. Busses are supposed to arrive every 5 minutes. Collected data indicate that buses generally arrive at the station with an average delay of 1 minute and a variance of 2.0 min^2. Assume that the delay of each bus is statistically independent and log-normally distributed, and if a bus arrives within 30 seconds of the scheduled time it is not considered to be late. **(20)**

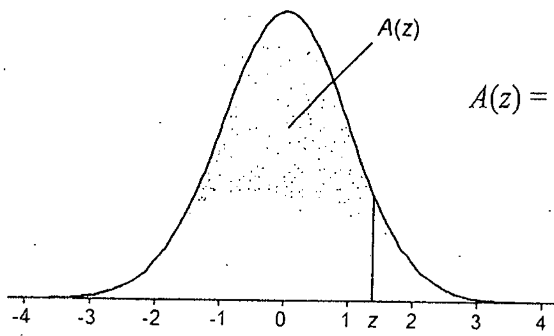
(i) What is the probability that a bus will arrive late at this station?

(ii) What is the probability that the first bus to arrive on time will be the third bus?

(iii) What is the probability that no bus will arrive at the station on time during the 1 hour of peak traffic?

(iv) If a bus is late, what is the probability that it will arrive within 1 minute of the scheduled time?

Cumulative Standard Normal Distribution



$A(z)$ = area corresponding to $Z \leq z$

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999							

Student's *t* Distribution

	Confidence Intervals, *c*					
	80%	90%	95%	98%	99%	99.9%
	Level of Significance for One-Tailed Test, α					
df	0.10	0.05	0.025	0.01	0.005	0.0005
	Level of Significance for Two-Tailed Test, α					
	0.20	0.10	0.05	0.02	0.01	0.001
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.599
3	1.638	2.353	3.182	4.541	5.841	12.924
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.869
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.408
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850

L-3/T-2/ME **Date : 23/07/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2014-2015

Sub : **ME 343** (Machine Design II)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Assume reasonable values of any missing data.

'Shigley's Mechanical Engineering Design' Text Book will be supplied.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A 02 series single row deep groove ball bearing is to be designed for an application with 3 kN axial load and 7 kN radial load. The outer ring will rotate at 500 rpm. The design reliability is 96% for a life of 30 khr. **(20)**

   Find:

   (i) The equivalent radial load on the bearing.

   (ii) Minimum basic load rating C_{10} required.

   (b) A 02-30 mm bore angular contact ball bearing which was subjected to 200,000 revolutions with a radial load of 18 kN, is to be used under a changed radial load of 30 kN condition. Estimate the expected life in revolution under this new loading condition. Assume other conditions remain unchanged. **(15)**

2. (a) A 32 mm × 32 mm sleeve bearing with 3.2 kN load rotates at 3600 rpm. SAE 10 lubricating oil is used with an average film temperature of 70°C. Estimate the radial clearance necessary to run the bearing in a minimum friction condition. **(20)**

   (b) Estimate the speed (rpm) at which a spur gear can be run to transmit 4 kW power with a design factor of safety 3 using Lewis's bending stress equation. The gear has 16 teeth with 3 mm module, 40 mm face width and 20° pressure angle. Use gear material yield strength as 250 MPa. **(15)**

3. (a) Briefly explain the advantages and drawbacks of journal and rolling contact bearings in consideration of their applications. **(10)**

   (b) Figure 3(b) shows an internal expanding type drum brake with hinges located as shown. The actuating forces on both shoes are F = 5 kN. The frition lining on the shoes are located centrally leaving a gap of 20° on both ends of the shoe. The mean coefficient of friction is 0.28. The inner diameter of drum is 300 mm, face width of the shoes are 50 mm, and radial distance of hinge pin from drum center is 120 mm. Assume the drum is rotating clockwise. **(25)**

Contd P/2

ME 343

Contd... Q. No. 3(b)

Find:

(i) Maximum pressure on the brake liner. Which shoe will be subjected to this maximum pressure?

(ii) Estimate the total braking capacity.

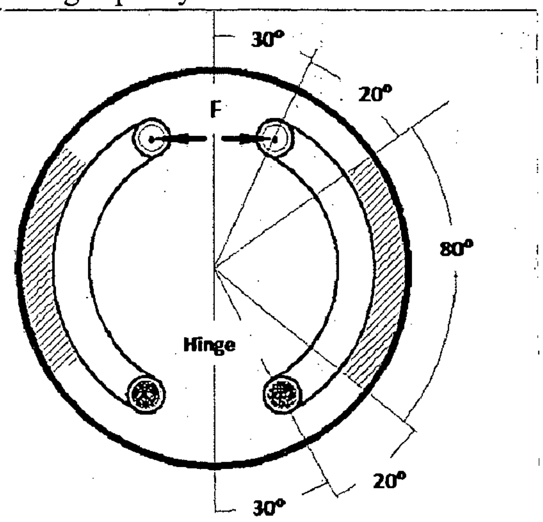


Fig for Q 3.(b)

4. A helical gear set has been selected to transmit input power of 3.5 kW. The pinion has 16 teeth with 20° normal pitch angle and 25° helix angle. The pinion rotates at 1500 rpm meshing with a 50 tooth helical gear. The normal module is 5 mm, face width is 50 mm, the gears have a quality number of 7. The pinion and gear material hardnesses are 240 HB and 200 HB respectively. Transmission is uniform. Assume pinion life of 10^7 cycles and reliability of 90%. Both gears are made with grade 2 through hardened steel. **(35)**

(i) Calculate the factors of safety for the bending and wear of the **pinion only**.

(ii) Based on the factors of safety which mode of failure is most likely to occurs first?

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) A single rope of designation 20 mm 6 × 19 IPS, regular lay, is used to lift a load of 1400 kg by a skip from a depth of 300 m. Self-weight of the skip is 900 kg. **(17)**

Take: D = 68d, E_r = 83 GPa, maximum acceleration during lifting the load is 2 m/s^2. Determine,

(i) static safety factor considering bending effect.

(ii) the life of rope if the fatigue safety factor considering bending effect is 2.

(iii) the maximum elongation.

(b) The smaller pulley (d = 200 mm) of a V-belt drive is directly connected to a 8 kW motor running at 1450 rpm. Multiple B3000 belts are to be selected with K_s = 1.4 and n_d = 1.1, D = 300 mm. Determine- **(18)**

(i) Number of belts required.

(ii) Fatigue safety factor.

(iii) Initial tension.

(iv) Belt life in khr.

Take, k_b = 65.1 N.m

Contd P/3

6. An electric motor (H = 2.5 hp, 1450 rpm) is directly coupled to a double threaded worm (material: High-test C.I.). The worm drives a 50 tooth gear (material: sand-cast bronze) that in turn runs a machine. **(35)**

Given: $\phi_n = 25^\circ$, $m_t = \frac{1}{5}$ inch, $d_w = 2$ inch, $F_e = 1.5$ inch, load application factor = 1.25, design factor = 1, 1 hp = 33000 $\frac{ft-lb}{\min}$, lateral area of gear case = twice the minimum lateral area recommended by AGMA. Determine: (i) gear rpm (ii) separating force between gear and worm (iii) efficiency of the drive (iv) safety factors by AGMA equation and also by Buckingham wear load equation (v) temperature rise of sump oil if a cooling fan is on.

7. (a) A pair of straight bevel gears (material: steel, grade 2, BHN = 200) have following data: driver pinion ($N_p = 50$) runs at 400 rpm and transmits 8 kW to the gear ($N_g = 100$), m = 15 mm at large end, b = 80 mm, $\phi_n = 20^\circ$, R = 95%, n_L (pinion) = 8×10^3 cycles, Q_v = 6, temperature = 70°C, both gears have smooth and uniform motion, they have uncrowned teeth and they are not straddle mounted. Find safety factor guarding against surface failure. **(18)**

(b) A double stranded ANSI 160 roller chain is selected to transmit a nominal power of 50 kW at 300 rpm with $K_s = 1.4$ and $n_d = 1.5$ in a rough environment. **(17)**

Given: $C/p = 25$, $N_1 = 17$, $N_2 = 51$. Determine (i) speed ratio, $\Delta V/V$ (ii) fatigue safety factor (iii) bending force on the driving shaft based on the design power (iv) required lubrication type.

8. (a) Design data of a helical compression spring are as follows: **(20)**

ends: squared and ground

material: 302 stainless steel (peened), $\gamma = 82 \times 10^{-6} \frac{N}{mm^3}$.

wire dia: 6 mm, spring index: 10, free length: 315 mm.

The spring deflects by 77.29 mm under a dead weight (F_m) of 400 N. Next, a fluctuating load (F_a) of 300 N is applied to it.

Determine (i) spring constant, number of active turns and solid height (ii) chance of collapse/buckling (iii) fatigue safety factor by Sine's criterion. Use Zimmerli's data. (iv) the spring's response, if frequency of F_a is 53.92 Hz.

(b) An automobile leaf spring carrier a total vertical load of 8 kN, so that half of this load acts on each tip (eye). The spring has 10 leaves, each leaf has a width of 80 mm and a thickness of 10 mm. Total span of the main leaf is 500 mm. Take, E = 200 GPa. **(15)**

(i) With a free hand sketch show the dimensions of a triangular flat spring that is equivalent to half of the leaf spring.

(ii) Find energy absorbed by the leaf spring because of the 8 kN load.

L-3/T-2/ME **Date : 27/07/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2014-2015

Sub : **ME 303** (Convection, Boiling, Condensation and Mass Transfer)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Assume reasonable values for missing data. All symbols have their usual meaning.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Define Grashof number, Prandtl number and Nusselt number. Using dimensional analysis, show that for natural convection heat transfer over a flat plate, $\text{Nu} = f(\text{Gr}, \text{Pr})$. **(17)**

(b) Oil flow in a journal bearing can be treated as parallel flow between two large isothermal plates with one plate moving at a constant velocity of 12 m/s and the other stationary. Consider such a flow with a uniform spacing of 0.7 mm between the plates. The temperature of the upper and lower plates are 40°C an 15°C, respectively. By simplifying and solving the continuity, momentum and energy equations, determine (i) the velocity and temperature distributions in the oil, and (ii) the maximum temperature and where it occurs. **(18)**

2. (a) A 1.0-kW heater is constructed of a glass plate with an electrically conducting film which produces a constant heat flux. The plate is 60 by 60 cm and placed in an airstream at 27°C, 1 atm with u_α = 5 m/s. Calculate the average temperature difference along the plate and the temperature difference at the trailing edge. **(20)**

(b) Air at 27°C and 1 atm flows over a 20-cm square flat plate at a free-stream speed of 20 m/s. The last half of the plate is heated to a constant temperature of 350 K. Calculate the heat lost by the plate. **(15)**

3. (a) How is the thermal entry length defined for flow in a tube? In what region is the flow in a tube fully developed? **(5)**

(b) Draw the temperature profiles of the developing and the fully developed thermal boundary layers inside a circular pipe when (i) the pipe wall is subjected to a constant heat flux and (ii) the pipe wall is maintained at the constant temperature. **(10)**

(c) In a parabolic trough concentrator, solar energy is collected by placing a tube at the focal line of the collector and passing fluid through the tube. The arrangement resulting in a uniform heat flux of 2000 W/m^2 along the axis of the tube of diameter 60 mm. Calculate (i) the length of the tube required to heat water from 20°C to 80°C, which flows at the rate of 0.01 kg/s and (ii) the surface temperature at the outlet of the tube. **(20)**

Contd P/2

4. (a) A 28-cm-high, 18-cm-long, and 18-cm-wide rectangular container suspended in a room at 24°C is initially filled with cold water at 2°C. The surface temperature of the container is observed to be nearly the same as the water temperature inside. The emissivity of the container surface is 0.8, and the temperature of the surrounding surfaces is about the same as the air temperature. Determine the water temperature in the container after 3 h, and the average rate of heat transfer to the water. Assume the heat transfer coefficient on the top and bottom surfaces to be the same as that on the side surfaces. **(20)**

(b) A horizontal pipe 0.30 m in diameter is maintained at a temperature of 250°C in a room where the ambient air is at 15°C. Calculate the heat transfer coefficient and the free convection heat loss per unit meter of length. **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Write down the mechanism of condensation heat transfer over a vertical tube and discuss. **(7)**

(b) What are the differences between film-wise and dropwise condensation? In which case you will expect more heat flux and why? **(8)**

(c) Calculate the average heat transfer coefficient for film-wise condensation of pure water-vapor at atmospheric pressure for the following cases: **(20)**

(i) a vertical plate of 1 meter in length.

(ii) the outside-surface of a vertical cylinder of 1.5 cm OD and 1 meter in length.

(iii) the outside surface of a horizontal cylinder 1.5 cm OD and 1 meter length.

(iv) Discuss your findings that you have obtained in the above cases.

In all cases, assume that the surface temperature is constant at 35°C below the saturation temperature. The following properties of the condensate may be assumed: $k_e = 0.65$ W/m°C, $\rho_e = 998$ kg/m^3, $h_{fg} = 2400$ kJ/kg, $\mu_e = 0.562\times10^{-3}$ kg/m-sec.

6. (a) Give a sketch of a typical pool boiling curve for a surface in a pool of water at atmospheric pressure. Describe the influence of relevant factors affecting the nucleate boiling heat transfer. **(15)**

(b) What are the differences between nucleate and film boiling heat transfer? Explain the importance of radiation on film boiling heat transfer. **(10)**

(c) Describe the methods of enhancing flow boiling heat transfer. **(10)**

Contd P/3

7. (a) A wet garment is hung on a wall for drying. Write down the one dimensional mass transfer equation with appropriate initial and boundary conditions and discuss. **(10)**

(b) In order to avoid over pressurization as well as maintain a pressure close to one atm, an industrial pipe-line containing ammonia gas is vented to ambient air. Ventag is achieved by tapping the pipe line and inserting 3 mm diameter tube, which extends upto 15 mm into the atmosphere. With the entire system operating at 25°C, calculate **(15)**

(i) the mass rate of contamination of the atmospheric air with ammonia in kg/hr.

(ii) the mass rate of air diffused with ammonia in the pipe

Assume mass diffusivity of ammonia in air = 0.29×10^{-4} m^2/sec, molecular weight of ammonia 17 kg/kmol, molecular weight of air 29 kg/kmol and R = 8.3×10^{-2} m^3 atm/kmol K.

(c) Discuss the relation $\text{Sh} = f(\text{Re}, \text{Sc})$, where the symbols have their usual meanings. **(10)**

8. (a) A heat exchanger is to be designed to cool 8.7 kg/sec an ethyl alcohol solution ($c_p = 3800$ J/kg°C) from 80°C to 50°C with cooling water ($c_p = 4200$ J/kg°C) entering the tube side at 15°C at a rate of 9.8 kg/sec. The overall heat transfer coefficient based on the outer tube surface is 510 W/m^2 °C. Calculate the heat transfer area for each of the following flow arrangements: **(20)**

(i) parallel flow, shell and tube.

(ii) counter flow, shell and tube.

(iii) one shell pass two tube passes.

(iv) cross-flow both fluids unmixed.

(v) discuss the results that you have obtained.

(b) Describe the importance of ε-NTU methods of heat exchanger analysis. **(6)**

(c) Write short notes on the following: **(9)**

(i) Fouling of heat exchanger.

(ii) Compact heat exchanger.

(iii) Regenerative heat exchanger.

TABLE A-13

Properties of liquids

Temp. T, °C	Density ρ, kg/m³	Specific Heat c_p, J/kg·K	Thermal Conductivity k, W/m·K	Thermal Diffusivity α, m²/s	Dynamic Viscosity μ, kg/m·s	Kinematic Viscosity ν, m²/s	Prandtl Number Pr	Volume Expansion Coeff. β, 1/K
				Engine Oil (unused)				
0	899.0	1797	0.1469	9.097×10^{-8}	3.814	4.242×10^{-3}	46,636	0.00070
20	888.1	1881	0.1450	8.680×10^{-8}	0.8374	9.429×10^{-4}	10,863	0.00070
40	876.0	1964	0.1444	8.391×10^{-8}	0.2177	2.485×10^{-4}	2,962	0.00070
60	863.9	2048	0.1404	7.934×10^{-8}	0.07399	8.565×10^{-5}	1,080	0.00070
80	852.0	2132	0.1380	7.599×10^{-8}	0.03232	3.794×10^{-5}	499.3	0.00070
100	840.0	2220	0.1367	7.330×10^{-8}	0.01718	2.046×10^{-5}	279.1	0.00070
120	828.9	2308	0.1347	7.042×10^{-8}	0.01029	1.241×10^{-5}	176.3	0.00070
140	816.8	2395	0.1330	6.798×10^{-8}	0.006558	8.029×10^{-6}	118.1	0.00070
150	810.3	2441	0.1327	6.708×10^{-8}	0.005344	6.595×10^{-6}	98.31	0.00070

Summary of Correlation for Forced Convection Flow over Flat Plates

Properties evaluated at Film temperature

Type	Restrictions	Fluid Flow	Heat Transfer: Isothermal (T_w = constant)	Heat Transfer: Isoflux (q_w = constant)
Local	Laminar: $Re_x < 5 \times 10^5$, $0.6 < Pr < 50$	$C_{f,x} = 0.664 Re_x^{-1/2}$	$Nu_x = 0.332 Re_x^{1/2} Pr^{1/3}$	$Nu_x = 0.453 Re_x^{1/2} Pr^{1/3}$
Average	Laminar: $Re_L < 5 \times 10^5$, $0.6 < Pr < 50$	$C_f = 1.328 Re_L^{-1/2}$	$Nu_L = 0.664 Re_L^{1/2} Pr^{1/3}$	$Nu_L = 0.680 Re_L^{1/2} Pr^{1/3}$
Local	Turbulent: $5 \times 10^5 \le Re_x \le 10^7$, $0.6 \le Pr \le 60$	$C_{f,x} = 0.059 Re_x^{-1/5}$	$Nu_x = 0.0296 Re_x^{4/5} Pr^{1/3}$	$Nu_x = 0.0308 Re_x^{4/5} Pr^{1/3}$
Average	Turbulent: $5 \times 10^5 \le Re_L \le 10^7$, $0.6 \le Pr \le 60$	$C_f = 0.074 Re_L^{-1/5}$	$Nu_L = 0.037 Re_L^{4/5} Pr^{1/3}$	$Nu_L = 0.037 Re_L^{4/5} Pr^{1/3}$
Average	ξ = unheated starting length; Laminar: $Re_L < 5 \times 10^5$; p = 2; Turbulent: $5 \times 10^5 \le Re_L \le 10^7$; p = 8	$Nu_L = Nu_{L(\text{for } \xi=0)} \left(\frac{L}{L-\xi}\right)\left[1-\left(\frac{\xi}{L}\right)^{\frac{p+1}{p+2}}\right]^{\frac{p}{p+1}}$		

Table A-5 | Properties of air at atmospheric pressure.†

The values of μ, k, c_p, and Pr are not strongly pressure-dependent and may be used over a fairly wide range of pressures

T, K	ρ kg/m³	c_p kJ/kg·°C	$\mu \times 10^5$ kg/m·s	$\nu \times 10^6$ m²/s	k W/m·°C	$\alpha \times 10^4$ m²/s	Pr
100	3.6010	1.0266	0.6924	1.923	0.009246	0.02501	0.770
150	2.3675	1.0099	1.0283	4.343	0.013735	0.05745	0.753
200	1.7684	1.0061	1.3289	7.490	0.01809	0.10165	0.739
250	1.4128	1.0053	1.5990	11.31	0.02227	0.15675	0.722
300	1.1774	1.0057	1.8462	15.69	0.02624	0.22160	0.708
350	0.9980	1.0090	2.075	20.76	0.03003	0.2983	0.697
400	0.8826	1.0140	2.286	25.90	0.03365	0.3760	0.689
450	0.7833	1.0207	2.484	31.71	0.03707	0.4222	0.683
500	0.7048	1.0295	2.671	37.90	0.04038	0.5564	0.680
550	0.6423	1.0392	2.848	44.34	0.04360	0.6532	0.680
600	0.5879	1.0551	3.018	51.34	0.04659	0.7512	0.680
650	0.5430	1.0635	3.177	58.51	0.04953	0.8578	0.682
700	0.5030	1.0752	3.332	66.25	0.05230	0.9672	0.684
750	0.4709	1.0856	3.481	73.91	0.05509	1.0774	0.686
800	0.4405	1.0978	3.625	82.29	0.05779	1.1951	0.689
850	0.4149	1.1095	3.765	90.75	0.06028	1.3097	0.692
900	0.3925	1.1212	3.899	99.3	0.06279	1.4271	0.696
950	0.3716	1.1321	4.023	108.2	0.06525	1.5510	0.699
1000	0.3524	1.1417	4.152	117.8	0.06752	1.6779	0.702
1100	0.3204	1.160	4.44	138.6	0.0732	1.969	0.704
1200	0.2947	1.179	4.69	159.1	0.0782	2.251	0.707
1300	0.2707	1.197	4.93	182.1	0.0837	2.583	0.705
1400	0.2515	1.214	5.17	205.5	0.0891	2.920	0.705
1500	0.2355	1.230	5.40	229.1	0.0946	3.262	0.705
1600	0.2211	1.248	5.63	254.5	0.100	3.609	0.705
1700	0.2082	1.267	5.85	280.5	0.105	3.977	0.705
1800	0.1970	1.287	6.07	308.1	0.111	4.379	0.704
1900	0.1858	1.309	6.29	338.5	0.117	4.811	0.704
2000	0.1762	1.338	6.50	369.0	0.124	5.260	0.702
2100	0.1682	1.372	6.72	399.6	0.131	5.715	0.700
2200	0.1602	1.419	6.93	432.6	0.139	6.120	0.707
2300	0.1538	1.482	7.14	464.0	0.149	6.540	0.710
2400	0.1458	1.574	7.35	504.0	0.161	7.020	0.718
2500	0.1394	1.688	7.57	543.5	0.175	7.441	0.730

Table A-9 | Properties of water (saturated liquid).†

Note: $Gr_x Pr = \left(\frac{g\beta\rho^2 c_p}{\mu k}\right) x^3 \Delta T$

°F	°C	c_p kJ/kg·°C	ρ kg/m³	μ kg/m·s	k W/m·°C	Pr
32	0	4.225	999.8	1.79×10^{-3}	0.566	13.25
40	4.44	4.208	999.8	1.55	0.575	11.35
50	10	4.195	999.2	1.31	0.585	9.40
60	15.56	4.186	998.6	1.12	0.595	7.88
70	21.11	4.179	997.4	9.8×10^{-4}	0.604	6.78
80	26.67	4.179	995.8	8.6	0.614	5.85
90	32.22	4.174	994.9	7.65	0.623	5.12
100	37.78	4.174	993.0	6.82	0.630	4.53
110	43.33	4.174	990.6	6.16	0.637	4.04
120	48.89	4.174	988.8	5.62	0.644	3.64
130	54.44	4.179	985.7	5.13	0.649	3.30
140	60	4.179	983.3	4.71	0.654	3.01
150	65.55	4.183	980.3	4.3	0.659	2.73
160	71.11	4.186	977.3	4.01	0.665	2.53
170	76.67	4.191	973.7	3.72	0.668	2.33
180	82.22	4.195	970.2	3.47	0.673	2.16
190	87.78	4.199	966.7	3.27	0.675	2.03
200	93.33	4.204	963.2	3.06	0.678	1.90
220	104.4	4.216	955.1	2.67	0.684	1.66
240	115.6	4.229	946.7	2.44	0.685	1.51
260	126.7	4.250	937.2	2.19	0.685	1.36
280	137.8	4.271	928.1	1.98	0.685	1.24
300	148.9	4.296	918.0	1.86	0.684	1.17
350	176.7	4.371	890.4	1.57	0.677	1.02
400	204.4	4.467	859.4	1.36	0.665	1.00
450	232.2	4.585	825.7	1.20	0.646	0.85
500	260	4.731	785.2	1.07	0.616	0.83
550	287.7	5.024	735.5	9.51×10^{-5}		
600	315.6	5.703	678.7	8.68		

Summary of Correlations for External Natural Convection

Geometry	Correlation(s)	Restrictions	Evaluation of Fluid Properties	Thermal condition
Vertical Plate	McAdams: $Nu_L = 0.59 Ra_L^{1/4}$	$10^4 < Ra_L < 10^9$	$T_f = (T_s + T_\infty)/2$	Isothermal
	McAdams: $Nu_L = 0.10 Ra_L^{1/3}$	$10^9 < Ra_L < 10^{13}$		
	Churchill and Chu: $Nu_L = 0.68 + \dfrac{0.670\, Ra_L^{1/4}}{\left[1+(0.492/Pr)^{9/16}\right]^{4/9}}$	$10^{-1} < Ra_L < 10^9$		
	Churchill and Chu: $Nu_L = \left\{0.825 + \dfrac{0.387\, Ra_L^{1/6}}{\left[1+(0.492/Pr)^{9/16}\right]^{8/27}}\right\}^2$	$10^{-1} < Ra_L < 10^{12}$		
	$Nu_x = 0.60(Gr_x^* Pr)^{1/5}$ $Nu_L = 1.25[Nu_x]_{x=L}$	$10^5 < Gr_x^* Pr < 10^{11}$ $Gr_x^* = \dfrac{g\beta q_w x^4}{k\upsilon^2}$	$T_f = (T_s + T_\infty)/2$, T_s is average surface temperature	Isoflux
	$Nu_x = 0.17(Gr_x^* Pr)^{1/4}$ $Nu_L = 1.136[Nu_x]_{x=L}$	$2\times10^{13} < Gr_x^* Pr < 10^{16}$		
Horizontal Cylinder	$Nu_D = 0.53(Gr_D Pr)^{1/4}$	$Pr > 0.5$, $10^3 < Gr_D < 10^9$	$T_f = (T_s + T_\infty)/2$, for gases $\beta = 1/T_f$	Isothermal
	$Nu_D = 0.53(Gr_D Pr^2)^{1/4}$	Liquid metals, $10^3 < Gr_D < 10^9$		
	Churchill and Chu: $Nu_D = 0.36 + \dfrac{0.518\, Ra_D^{1/4}}{\left[1+(0.559/Pr)^{9/16}\right]^{4/9}}$	$10^{-6} < Ra_D < 10^9$		
	Churchill and Chu: $Nu_D = \left\{0.60 + \dfrac{0.387\, Ra_D^{1/6}}{\left[1+(0.559/Pr)^{9/16}\right]^{8/27}}\right\}^2$	$10^{-5} < Ra_D < 10^{12}$		

TABLE 8.4 Summary of convection correlations for flow in a circular tube[a,b,e]

Correlation		Conditions
$f = 64/Re_D$	(8.19)	Laminar, fully developed
$Nu_D = 4.36$	(8.53)	Laminar, fully developed, uniform q_s''
$Nu_D = 3.66$	(8.55)	Laminar, fully developed, uniform T_s
$\overline{Nu}_D = 3.66 + \dfrac{0.0668\, Gz_D}{1 + 0.04\, Gz_D^{2/3}}$	(8.57)	Laminar, thermal entry (or combined entry with $Pr \gtrsim 5$), uniform T_s, $Gz_D = (D/x)\, Re_D\, Pr$
$\overline{Nu}_D = \dfrac{\dfrac{3.66}{\tanh[2.264\, Gz_D^{-1/3} + 1.7\, Gz_D^{-2/3}]} + 0.0499\, Gz_D \tanh(Gz_D^{-1})}{\tanh(2.432\, Pr^{1/6}\, Gz_D^{-1/6})}$	(8.58)	Laminar, combined entry, $Pr \gtrsim 0.1$, uniform T_s, $Gz_D = (D/x)\, Re_D\, Pr$
$\dfrac{1}{\sqrt{f}} = -2.0 \log\left[\dfrac{e/D}{3.7} + \dfrac{2.51}{Re_D\sqrt{f}}\right]$	(8.20)[c]	Turbulent, fully developed
$f = (0.790 \ln Re_D - 1.64)^{-2}$	(8.21)[c]	Turbulent, fully developed, smooth walls, $3000 \lesssim Re_D \lesssim 5 \times 10^6$
$Nu_D = 0.023\, Re_D^{4/5}\, Pr^n$	(8.60)[d]	Turbulent, fully developed, $0.6 \lesssim Pr \lesssim 160$, $Re_D \gtrsim 10{,}000$, $(L/D) \gtrsim 10$, $n = 0.4$ for $T_s > T_m$ and $n = 0.3$ for $T_s < T_m$
$Nu_D = 0.027\, Re_D^{4/5}\, Pr^{1/3}\left(\dfrac{\mu}{\mu_s}\right)^{0.14}$	(8.61)[d]	Turbulent, fully developed, $0.7 \lesssim Pr \lesssim 16{,}700$, $Re_D \gtrsim 10{,}000$, $L/D \gtrsim 10$
$Nu_D = \dfrac{(f/8)(Re_D - 1000)\, Pr}{1 + 12.7(f/8)^{1/2}(Pr^{2/3} - 1)}$	(8.62)[d]	Turbulent, fully developed, $0.5 \lesssim Pr \lesssim 2000$, $3000 \lesssim Re_D \lesssim 5 \times 10^6$, $(L/D) \gtrsim 10$

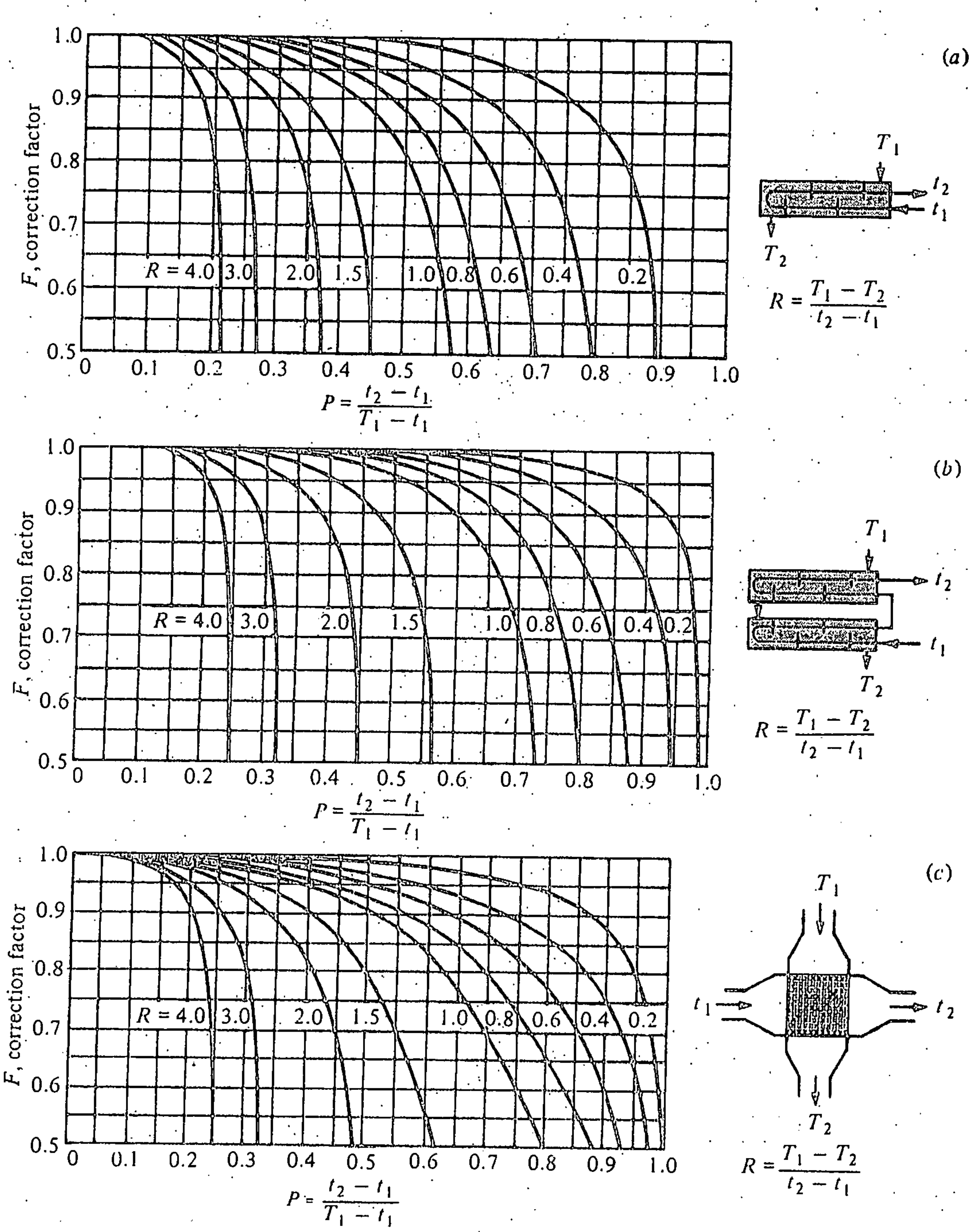


Figure 11-16 Correction factor F for computing $\Delta T_{\text{corrected}}$ for multipass and cross-flow exchangers. (*a*) One shell pass and two tube pass or multiple of two tube pass; (*b*) two shell pass and four tube pass or multiple of four tube pass; (*c*) single-pass, cross-flow, both fluids unmixed. (*From Bowman, Mueller, and Nagle* [45].)

$$h_m = 0.943\left[\frac{g\rho_l(\rho_l - \rho_v)h_{fg}k_l^3}{\mu_l(T_v - T_w)L}\right]^{1/4}$$

$$h_m = 0.725\left[\frac{g\rho_l(\rho_l - \rho_v)h_{fg}k_l^3}{\mu_l(T_v - T_w)D}\right]^{1/4}$$

L-3/T-2/ME **Date : 01/08/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2014-2015

Sub : **ME 323** (Fluid Mechanics II)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

The figures in the margin indicate full marks.

Moody diagram and Isentropic Flow Table are attached.

1. (a) Distinguish between Couette flow and Poiseuille flow. **(5)**

(b) Derive the velocity distribution in a laminar flow between two parallel plates, with the upper plate moving with velocity *U*. List all assumptions used in the derivation. **(15)**

(c) Derive the expressions for pressure drop and friction factor as functions of average velocity in a laminar flow between two parallel stationary plates. **(15)**

2. (a) Explain the terms (i) apparent shear stress and (ii) eddy viscosity in a turbulent flow. **(8)**

(b) What is minor loss? Determine the flow rate through the pipe shown in Fig. Q2b. Loss coefficients are: Square edge entrance = 0.5, standard 4cm screwed elbow = 0.95. **(20)**

(c) What is hydraulic radius? Water at 20°C is transported at 0.01 m/s velocity through a smooth horizontal conduit of 2 cm × 4 cm cross section. Determine the hydraulic radius and the Reynolds number for this flow. **(7)**

3. (a) Discuss the mechanism, conditions and adverse effects of flow separation. How can the flow separation be avoided? **(10)**

(b) Write short notes on: (i) Kármán vortex street and (ii) Stall condition of an airfoil. **(10)**

(c) Show that for an isentropic flow through a nozzle, the relationship between flow area and velocity depends on the Mach number of the flow. **(15)**

4. (a) What is shock wave? Show that the Mach numbers upstream and downstream of a normal shock wave are linked as **(25)**

$$M_2^2 = \frac{M_1^2 + \frac{2}{k-1}}{\frac{2k}{k-1}M_1^2 - 1}$$

Then establish the relations of upstream and downstream Mach numbers, pressures and temperatures across a normal shock wave if the fluid is air.

(b) A converging-diverging nozzle, with an exit area of 40 cm^2 and a throat area of 10 cm^2, is attached to a reservoir with $T = 20°C$ and $p = 400$ kPa absolute. Determine the two exit pressures that result in $M = 1$ at the throat for an isentropic flow. Also, determine the associated exit temperatures and velocities and flow rates. **(10)**

Contd P/2

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

The questions are of equal value. Assume reasonable data if necessary.

5. (a) With the help of diagrams explain the different types of similarities which may exist between a model and its prototype.

   (b) A pipe of diameter 1.25 m is required to transport oil of specific gravity 0.85 and viscosity 3 Ns/m^2 at the rate of 2900 l/s. In order to model this flow, water is allowed to flow through a 150 mm diameter pipe having viscosity 1.1 Ns/m^2. Find the velocity and rate of flow in the model pipe.

6. (a) Discuss the Reynolds number, Froude number and Euler number giving illustrations of their significance. Explain Buckingham π-theorem for dimensional analysis.

   (b) The power P supplied by a centrifugal pump depends on volume flow rate of water Q, specific weight of water γ and head H. Using Buckingham π-theorem show that $P = f(Q, \gamma, H)$.

7. (a) What are the conditions of maximum velocity and maximum discharge through a circular open channel? Prove these conditions.

   (b) Water is flowing through a trapezoidal open channel having side slope of 1 horizontal to 2 vertical and the bed slope is 1 in 1600. The area of flow is 45 m^2. Find the dimensions of the channel and also the discharge if it is most economical. Take Chezy's constant C = 60.

8. (a) Explain boundary layer thickness. Derive the equations of displacement thickness and momentum thickness.

   (b) What is flowing at the rate of 0.20 m^3/s through a circular open channel of 0.7 m diameter. Calculate the slope of the bed of the channel considering maximum velocity of flow. Take Chezy's constant C = 65.

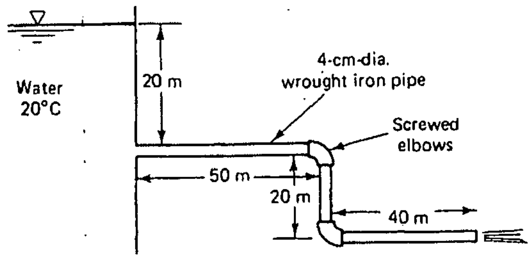


Figure for Q2b

Table 1: Isentropic Flow of a Perfect Gas, $k = 1.4$

M	p/p_0	T/T_0	A/A^*	M	p/p_0	T/T_0	A/A^*
0.00	1.0000	1.0000	∞	2.10	0.1094	0.5313	1.8369
0.10	0.9930	0.9980	5.8218	2.20	0.0935	0.5081	2.0050
0.20	0.9725	0.9921	2.9635	2.30	0.0800	0.4859	2.1931
0.30	0.9395	0.9823	2.0351	2.40	0.0684	0.4647	2.4031
0.40	0.8956	0.9690	1.5901	2.50	0.0585	0.4444	2.6367
0.50	0.8430	0.9524	1.3398	2.60	0.0501	0.4252	2.8960
0.60	0.7840	0.9328	1.1882	2.70	0.0430	0.4068	3.1830
0.70	0.7209	0.9107	1.0944	2.80	0.0368	0.3894	3.5001
0.80	0.6560	0.8865	1.0382	2.90	0.0317	0.3729	3.8498
0.90	0.5913	0.8606	1.0089	3.00	0.0272	0.3571	4.2346
1.00	0.5283	0.8333	1.0000	3.10	0.0234	0.3422	4.6573
1.10	0.4684	0.8052	1.0079	3.20	0.0202	0.3281	5.1210
1.20	0.4124	0.7764	1.0304	3.30	0.0175	0.3147	5.6286
1.30	0.3609	0.7474	1.0663	3.40	0.0151	0.3019	6.1837
1.40	0.3142	0.7184	1.1149	3.50	0.0131	0.2899	6.7896
1.50	0.2724	0.6897	1.1762	3.60	0.0114	0.2784	7.4501
1.60	0.2353	0.6614	1.2502	3.70	0.0099	0.2675	8.1691
1.70	0.2026	0.6337	1.3376	3.80	0.0086	0.2572	8.9506
1.80	0.1740	0.6068	1.4390	3.90	0.0075	0.2474	9.7990
1.90	0.1492	0.5807	1.5553	4.00	0.0066	0.2381	10.7188
2.00	0.1278	0.5556	1.6875				

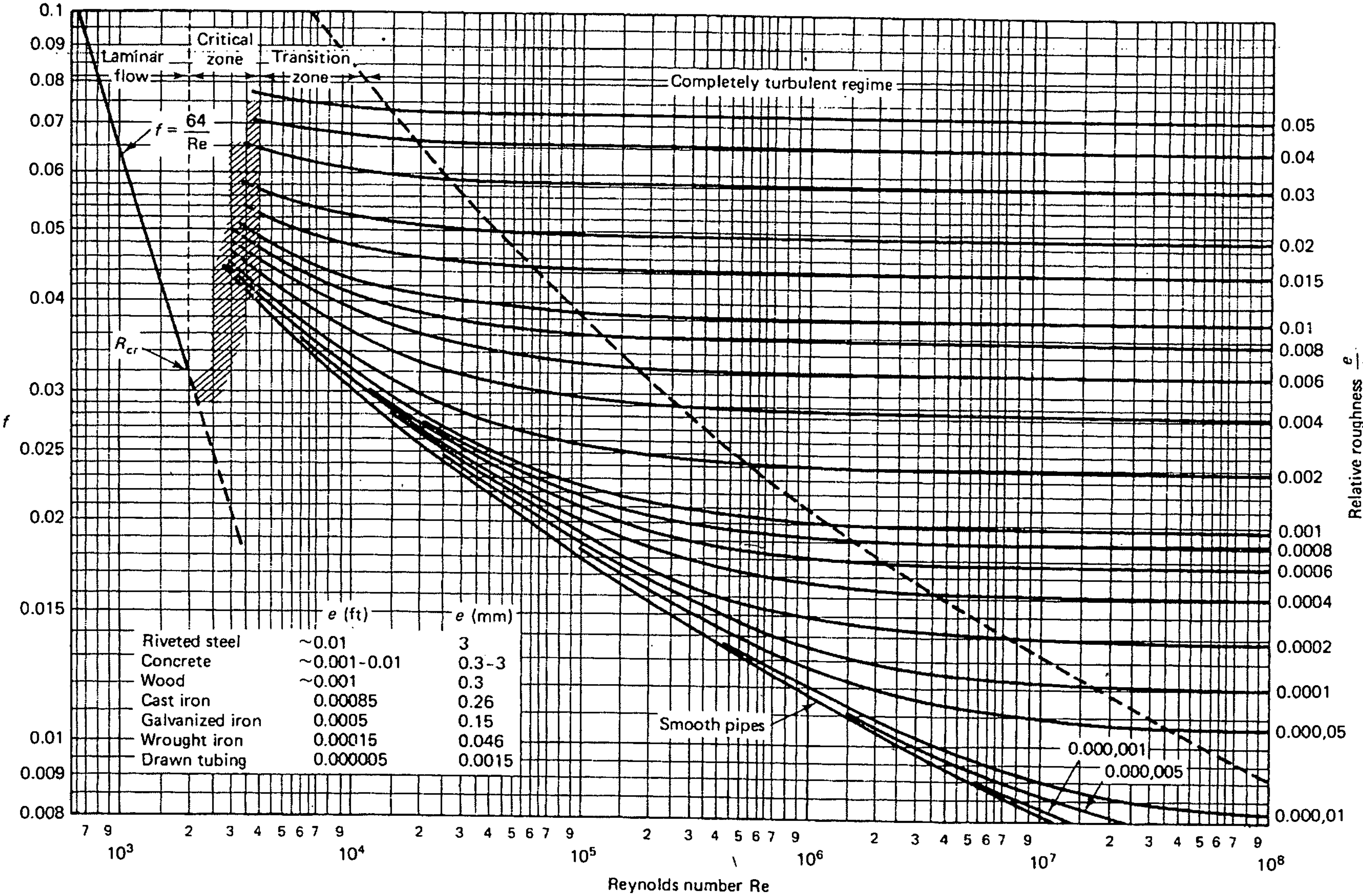


Figure 7.13 Moody diagram. (From L. F. Moody, *Trans. ASME*, Vol. 66, 1944.)